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## MEDIEVAL MORTAR MIXERS REVISITED Basle and Beyond

by

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*For Ludwig Berger and John H. Williams*

1. Introduction
2. The example from Basle-Cathedral Hill
  2. 1. *Excavations at Martinsgasse 6/8*
  2. 2. *The mortar mixer*
  2. 3. *Dating of the mortar mixer*
  2. 4. *The medieval stone building*
  2. 5. *A piece of enamelled gold-work*
  2. 6. *The northern part of Cathedral Hill in the Middle Ages*
    2. 6. 1. A royal court on Martinskirchsporn?
    2. 6. 2. The Holy Roman Emperor Henry II and Bishop Adalbero II
    2. 6. 3. Earlier phases of a royal court?
3. Mechanical mortar mixers in Europe
  3. 1. *History of research*
  3. 2. *Distribution*
  3. 3. *Dating*
  3. 4. *Technical details*
  3. 5. *Historical sources – illustrations and texts*
  3. 6. *Reconstructions – driving power*
4. Discussion and outlook
5. Gazetteer
6. Bibliography

### 1. Introduction<sup>1</sup>

In 2004 the well-preserved remains of a mortar mixer were excavated on the northern part of Cathedral Hill in Basle. Pieces of charcoal in the mortar disc were radiocarbon dated to the 10th or early 11th century AD. Together with foundations of a stone building, finds and other features this revived the discussion on the usage of the hill during the Middle Ages by the secular sovereign. The ecclesiastical counterparts would have been the cathedral and the living quarters of the bishop and his entourage (ministerials) located further south on the same elevation above the River Rhine.

Mechanical mortar mixers were closely linked to the renaissance of stone architecture between the 8th and the 11th centuries AD. They were usually associated with large building projects authorised by both ecclesiastical and secular rulers in the High Middle Ages.<sup>2</sup> More than ten years after the last comprehensive overview<sup>3</sup> and with twice the number of examples, this contribution aims to reassess the phenomenon citing more than 60 structures from 37 sites across Europe.

<sup>1</sup> I would like to thank John H. Williams, Sandy Haemmerle and Guido Helmig for extensive proof reading. Any mistakes regarding linguistics or the content, are mine alone. I also received great help from Peter von Holzen and the Archäologische Bodenforschung Basel-Stadt with the map and graphs.

<sup>2</sup> “[A]lmost invariably in association with sites of high status” (John H. Williams in Williams/Shaw/Denham 1985, 37).

<sup>3</sup> Cf. Burnell 1998.



Fig. 1 Basle, Martinsgasse 6/8 (excavation 2004/1). Excavation site on “Martinskirchsporn”, the northern part of Cathedral Hill; to the north in the background St. Martin’s Church and the River Rhine (photograph: Christian Stegmüller, Archäologische Bodenforschung Basel-Stadt).

## 2. The example from Basle-Cathedral Hill<sup>4</sup>

### 2. 1. Excavations at Martinsgasse 6/8<sup>5</sup>

Prompted by a development project the Archäologische Bodenforschung, the archaeology department of Canton Basel-Stadt, mounted extensive excavations on the northern part of Cathedral Hill (“Münsterhügel”) in 2004 (fig. 1). This part of the plateau is called “Martinskirchsporn” after the parish

church dedicated to St. Martin, a patron saint of the Franks in the 7th and 8th centuries AD.

The investigations carried out at Martinsgasse 6/8 yielded important new information on the historical development of this lesser known part of Cathedral Hill (fig. 3). 3000 years ago, in the Late Bronze Age, a fortified settlement stood on the northern end of the hill, as indicated by a ditch, some 2.5 m deep and 9 m wide.<sup>6</sup> Several pits showed that this part of Cathedral Hill had been used as a dwelling place around 50 BC, in the Late La Tène period. Around the same time a *muris gallicus*, a defensive structure in timber and stone, had been erected; this wall, together with an extensive ditch, separated the plateau from the high ground to the south.<sup>7</sup> In Late Roman times a fortification – probably a stone wall – had completely surrounded the plateau. Within the excavated area extensive layers of thick mortar and numerous fragments of worked stone attested to intensive building activity. The corner of a stone building further west within the passage between the modern inner courtyard and today’s Martinsgasse may date from the same period (fig. 4). Other areas of Cathedral Hill, especially from the area beneath and around the cathedral, also yielded remains of substantial Late Roman buildings. One may assume that some of these buildings had continued to be used and maintained into the medieval period<sup>8</sup>.

During the Early and High Middle Ages thick layers of so-called ‘dark earth’ accumulated in many places across the fortified plateau, apparently due to the fact that the edges of the plateau were fortified and thus raised, which prevented erosion downhill. A combination of consolidated surfaces, blocked drainage systems, debris from collapsed buildings and a change in the waste disposal methods led to a substantial rise in surface levels.

<sup>4</sup> The evaluation project in connection with the excavations at „Martinsgasse 6/8“ was led by Andrea Hagendorn. The outcome was a comprehensive manuscript on the medieval and modern structures and finds by the author. It is planned to be published together with Markus Asal’s PhD thesis on the Roman period and Regula Ackermann’s master thesis on the Late Celtic period from the same site. The Basle mortar mixer in its wider context was first presented at the congress “Medieval Europe Paris 2007”. That paper is available online as part of the proceedings of the congress: Stelzle-Hüglin 2007.

<sup>5</sup> Preliminary report: Hagendorn/Stegmüller/Stelzle-Hüglin 2006.

<sup>6</sup> Unter Uns 2008, 98.

<sup>7</sup> Unter Uns 2008, 140.

<sup>8</sup> Reto Marti assumes that a Late Roman granary (*horreum*) still stood on the site of present-day Münsterplatz, when the first stone-built church – the so-called Haitomünster (Cathedral of Bishop Haito) – was erected. A reconstruction drawing of this situation was presented as part of a recently staged exhibition on the archaeological research in Basle (Unter Uns 2008, 196, 252–253; Lassau 2009, 60). One argument supporting the idea of a continuity of buildings and functions from the Roman to medieval periods is that early 14th century sources still mention the nearby “Schürhof” or “Dinghof” – the central building of the episcopal administration for the collection of rent in kind.



Fig. 2 Basle, Martinsgasse 6/8 (excavation 2004/1). Bird's eye view of the excavation site in the inner courtyard of Martinsgasse 6/8. The remains of the mortar mixer are visible through the plastic of the makeshift roof (photograph: Christian Stegmüller, Archäologische Bodenforschung Basel-Stadt).

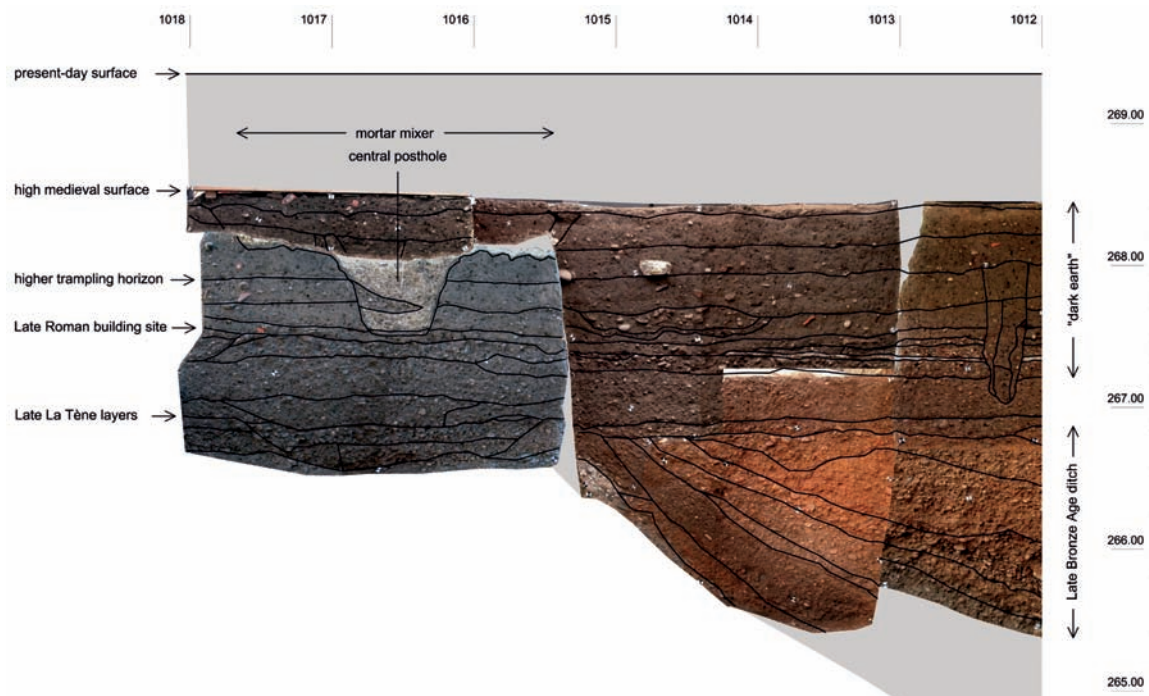


Fig. 3 Basle, Martinsgasse 6/8 (excavation 2004/1). Section through the layers: from the Late Bronze Age ditch on the lower right to Late La Tène and Late Roman horizons with a Late Roman mortar mixing area to early and high medieval 'dark earth' layers and the high medieval mortar mixer on the upper left. – Scale 1:35 (graphics: Peter von Holzen, Archäologische Bodenforschung Basel-Stadt).



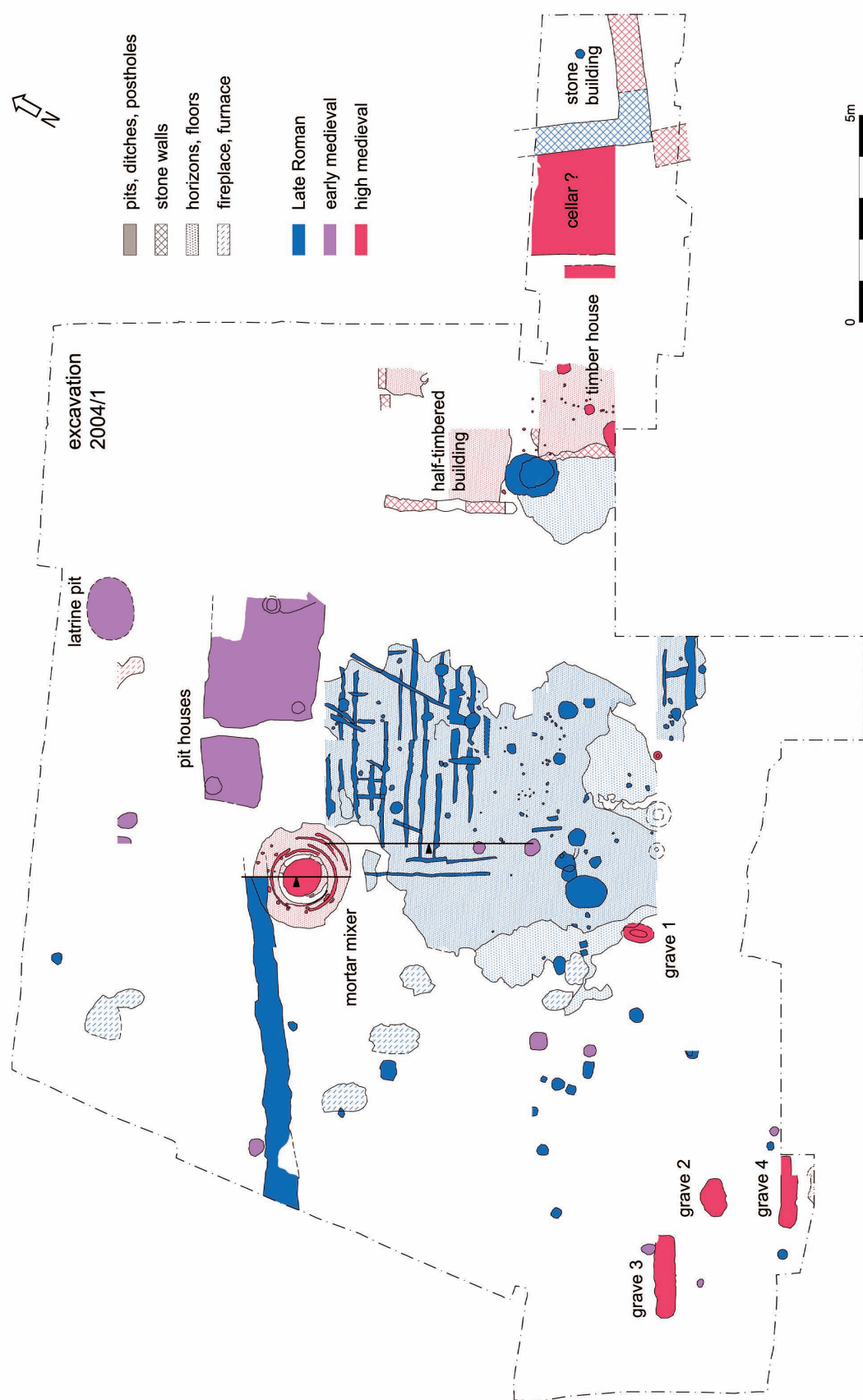


Fig. 4 Basle, Martingasse 6/8 (excavation 2004/1). General plan of the Late Roman to early and high medieval structures. The position of the section (fig. 3) is indicated. – Scale 1:150 (graphics: Peter von Holzen, Archäologische Bodenforschung Basel-Stadt).

## 2. 2. The mortar mixer

A horizontal disc of hardened mortar was found in the upper part of the 'dark earth' layers (fig. 5–6). It measured approximately 2.5 m in diameter and the associated pit was at least 0.3 m deep. There was a central posthole, measuring 0.5 m in diameter and cutting 0.5 m below the base of the circular pit. Four concentric, but not continuous grooves circling the central post hole were carved into the surface of the disc. The northern half of the roundel showed five pairs of small holes and two individual ones located at either side of the second groove from the centre dividing this half of the circle into five sections. The first pair of holes, when counting from the west, did not have round indentations like the others, but left elongated oval-shaped holes aligned along the groove. There were also a series of three holes set in an arc just outside the fourth groove.

The structure represents the remains of a mechanical mortar mixing device. An attempt has been made to ascertain how the Martinsgasse structure could have worked (fig. 7). A circular flat-based pit was dug to contain the mortar for mixing. At its centre was the hole for an upright post which would have acted as a pivot for a horizontal beam. One must assume that the beam rotated on a pivot around the upright post rather than that the beam was integral with the upright post, with the post rotating as well as the beam. Sticks firmly set into the underside of the beam would have acted as paddles to mix the mortar as the horizontal beam was rotated.

The upright sticks placed in the base of the pit at Basle were a special feature; they were arranged in pairs in order to allow one of the paddles fixed to the beam to pass between them. This so-called *Zwangsmischprinzip* or forced method of mixing must have considerably improved the mixing process.<sup>9</sup> The fact that the sticks were placed in one half of the pit only probably made it easier to remove the mortar in the end, the material being dragged into the open half for extraction. The beam with the paddles presumably rotated in a clockwise direction: this would explain the elongated holes created by the first two sticks. They would probably have been forced back by the mortar and the paddles after having rotated freely around the 'stick-free' half of the circle.

<sup>9</sup> Scheidegger 1999, 246 s.

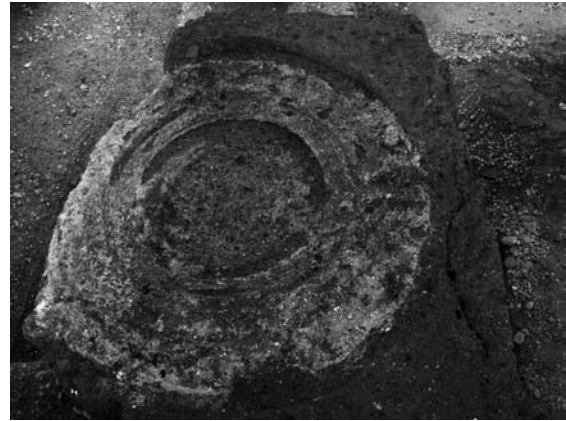


Fig. 5 Basle, Martinsgasse 6/8 (excavation 2004/1). The remains of the mortar mixer embedded in layers of 'dark earth'; diameter approximately 2.5 m (photograph: Christian Stegmüller, Archäologische Bodenforschung Basel-Stadt).

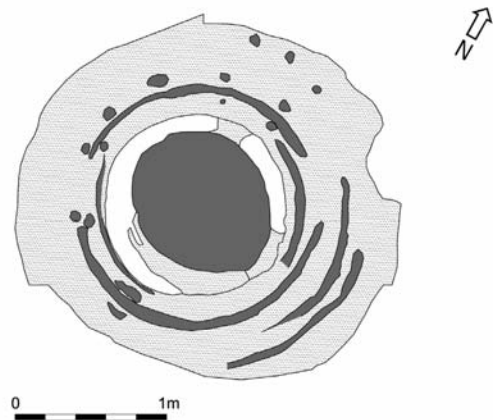


Fig. 6 Basle, Martinsgasse 6/8 (excavation 2004/1). The mortar mixer; schematical depiction of the interior structures. – Scale 1:50 (graphics: Peter von Holzen, Archäologische Bodenforschung Basel-Stadt).

An important question is how the rotating mechanism was kept in position. The central post would need to have been firmly embedded in the ground; additionally or alternatively there would have been a need for a superstructure that did not impede the persons or animals pushing the beams. At Basle, however, no post-holes to support such a structure were found. Moreover, with a superstructure one would have to consider how the rotating beam related to the central pivot both below and above it.

During the excavation samples were taken for the analysis of the micromorphology of the mortar layers in thin sections under the microscope. Philippe Rentzel and his team from the *Institute for Prehi-*

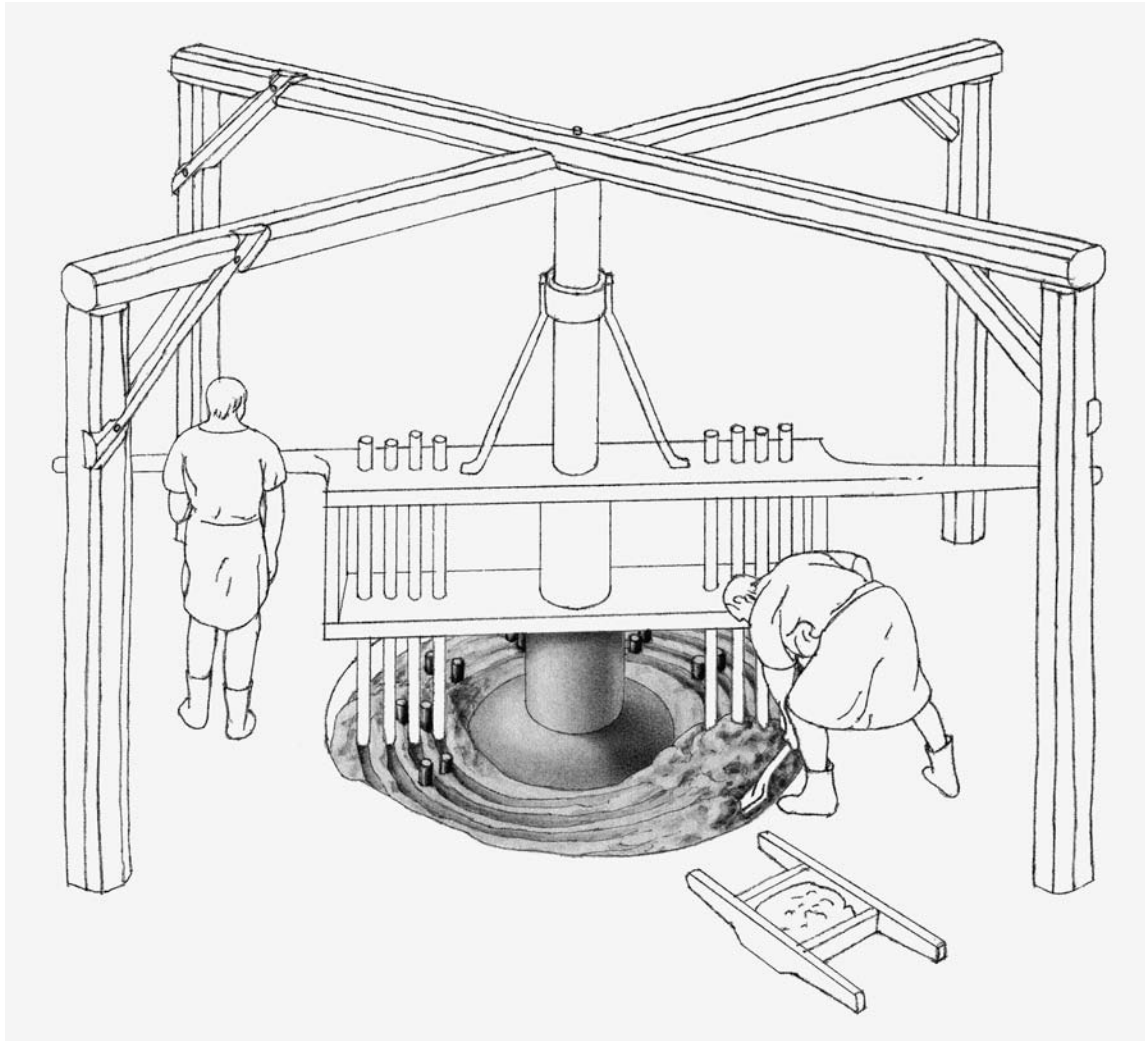


Fig. 7 Proposed reconstruction of the Basle mortar mixer: Added parts are left blank  
(illustration: Heidi Colombi, Archäologische Bodenforschung Basel-Stadt).

*story and Archaeological Science* (IPAS/IPNA) at the University of Basle were able to identify several mixing processes.

### 2. 3. Dating of the mortar mixer

Two levels within the 'dark earth' were identified as archaeological surfaces. The top level was probably formed at the beginning of the High Middle Ages around the 8th and 9th centuries AD. Both the layer associated with the mortar mixer and the surface associated with the reused Late Roman foundations, were situated at the upper end of the 'dark earth' strata and significantly higher than the archaeological surfaces mentioned (fig. 3).

Due to the fact that it proved difficult to date the 'dark earth' layers solely on the basis of the finds<sup>10</sup>, independent dating methods were employed. With the help of accelerated mass spectroscopy (AMS) Georges Bonani from the *Laboratory of Ion Beam Physics* (LIP) at the *Swiss Federal Institute of Technology* (ETH) in Zurich carried out radiocarbon dating of the carbon dioxide in the mortar on the one hand and of minute charcoal flecks extracted from the mortar on the other. While the analysis of the carbon dioxide was unsuccessful, two pieces of charcoal rendered results. A weighted mean was calculated and calibrated: with a probability of 71.8

<sup>10</sup> The bulk of the material dated from the Late Roman period, thus from the 3rd to 5th centuries AD.





Fig. 8 Basle, Martinsgasse 6/8 (excavation 2004/1). The walls in the passageway between the inner courtyard and Martinsgasse at a later stage of the excavation. On the left the remains of the supposedly Late Roman wall and on the right higher up the medieval wall (photograph: Christian Stegmüller, Archäologische Bodenforschung Basel-Stadt).

% the charcoal from the mortar dates from between AD 936 and 1018.

#### 2. 4. *The medieval stone building*

The installation of such a complex device must be seen in connection with a major construction project in the vicinity. It allowed large quantities of mortar to be produced, perhaps for rendering extensive wall surfaces or casting mortar floors. Mixers were usually constructed directly on the site as close to the building as possible and sometimes even inside the building itself so that mortar did not have to be carried far.

Two walls, one of which was located on a supposedly Late Roman wall, were the closest stone structures dating from the same period as the mixer (fig. 8). The later wall was aligned with the earlier wall and showed the same thickness. The surfaces associated with the earlier wall and the later wall differed by 0.5 m. Both walls measured 0.65 m in thickness: this suggests that the stone building only had a single stone-built storey, possibly with the addition of a (half-)timbered upper floor. The interior

of the earlier building would have been situated to the east; nothing is known about the layout and size of either one of the stone buildings. The position and orientation of both buildings clearly indicate that “Martinsgasse” as a roadway does not date back to late antiquity, but rather to a medieval phase of restructuring. This may have taken place in the 12th century, since the later phase of the stone building in question was demolished and covered over by layers containing fragments of pottery and stove tiles dating from that time.

#### 2. 5. *A piece of enamelled and enamelled jewellery*

An extraordinary piece of gold-work was found in the upper layers of the ‘dark earth’ between the mortar mixer and the remains of the stone building (fig. 9). Its conservation carried out at the restoration laboratory of the Historical Museum in Basle brought to light various details: the ring-shaped disc – 24 mm in diameter – with a raised edge was made of bronze; eight curved fillets formed cells inlaid with coloured frit. The background was covered with





Fig. 9 Basle, Martinsgasse 6/8 (excavation 2004/1). Gilded ring-shaped bronze disc with four peltas forming a cross with the cells in between filled with enamel in blue and red; diameter 24 mm; Inv.-N° 2004/1.390 (photograph: Philippe Saurbeck, Archäologische Bodenforschung Basel-Stadt).

blue translucent enamel; drops of opaque red glass were placed within the rolled ends of the tendrils and along the stems. Finally the face of the disc was polished and gilded.

The cross-shaped pelta ornament<sup>11</sup> and the type of enamelling find their closest parallels in Carolingian and Ottonian metalwork, for example among the widespread “Kreuz-” or “Emailscheibenfibeln”<sup>12</sup> and are also found on larger objects such as the „Adelhau- ser Tragaltar“. The decoration seen on the frame of this portable altar from the treasury of the Adelhau- sen Monastery in Freiburg im Breisgau (D), which has been dated to the first half of the 9th century, consists of rows of discs with blue and red enamel.<sup>13</sup>

The original function of the Basle piece remains unknown: if the disc had been mounted on fabric, one would expect to find traces of a pin on its back; no such traces are visible. The object may also have been a decoration fragment from a reliquary casket, paten or portable altar.

Two similar objects were recovered in earlier ex- cavations carried out in Basle: in 1851 a burial con-

taining several Late Roman coins and a high medieval enamelled saint’s brooch was discovered during the re- location of a fountain in front of St. Martin’s Church. The grave had probably belonged to a cemetery asso- ciated with a church preceding the actual St. Martin’s Church, which was first mentioned in 1011/3. Just 20 mm in diameter the brooch shows a strongly stylized portrait of the Virgin Mary.<sup>14</sup> Excavations carried out from 1937 to 1939 in the area of the former Petersberg quarter, nowadays a big building complex called “Spie- gelhof”, brought to light a disc brooch with filigree or- nament beneath the remains of high medieval timber buildings, which were preserved in waterlogged con- ditions close to where the mouth of the River Birsig enters the Rhine. Like the artefact from Martinsgasse, the brooch also bore a central motif consisting of four peltae forming a cross, in this case executed in filigree. The disc-shaped brooch – probably used to fasten a woman’s cloak – measured 58 mm in diameter and was cast in a tin-lead-alloy, imitating silver. A pin mount and bow were soldered onto its reverse. Together with five spurs, the brooch points to the presence of an elite in this urban dwelling site in the valley north of Cathedral Hill in the 10th–11th centuries AD.<sup>15</sup>

The enamelled and gilded ring-shaped disc from the excavation at “Martinsgasse 6/8” joins other ex- traordinary finds from the high medieval period in the region. Together with the saint’s brooch from the grave near St. Martin’s Church it attests to the important role of the northern end of Cathedral Hill as a centre of power within the medieval political geography of the Basle region.

## 2. 6. *The northern part of Cathedral Hill in the Middle Ages*

### 2. 6. 1. A royal court on Martinskirchsporn?

Who might have owned such an outstanding piece of gilded jewellery? Who would have had the means to have a house built on top of Late Roman foundations? One possible candidate – the Bishop of Basle – had his cathedral and his palace several hund-

<sup>11</sup> The Greek term *peltarion*, *pelta* or *pélte* was used only to refer to a crescent-shaped wicker shield. The term is now also used to describe certain types of ornaments mainly from antiquity.

<sup>12</sup> An enamelled circular disc brooch with similar pelta orna- ment was published by Giesler 1989, 234 ss., fig. 57k.

<sup>13</sup> Wilson 1986, 128, fig. 156; Zinke 2010, 24–25.

<sup>14</sup> Unter Uns 2008, 251 (essay by Reto Marti on the Early Middle Ages) and 379 (catalogue).

<sup>15</sup> Berger 1963, 40–43, pl. 20,1; Berger 2003, 154–155, fig. 7; 160–162, fig. 16–20; 166–167 (appendix 2); Unter Uns 2008, 260 (essay by Reto Marti on the Early Middle Ages) and 381 (catalogue).

red metres to the south-east at the other end of Cathedral Hill. Moreover, the Martinskirchsporn was at that stage separated from the rest of Cathedral Hill by a ditch.<sup>16</sup> Is it possible that Cathedral Hill was divided up between the ecclesiastical and secular powers for at least two hundred years, from the 10th to the 12th centuries AD?<sup>17</sup> Similar situations are known for example from the Île de France in Merovingian Paris or from medieval Bergen (in present-day Norway).

As early as 1963 Ludwig Berger mentioned the northern end of Cathedral Hill, the Martinskirchsporn, as the possible site of a royal residence, a “Königshof”.<sup>18</sup> He gave several reasons for suggesting that the Frankish kings may have had a court there: one aspect would have been the church dedicated to St. Martin and the fortified elevated terrain. Another argument would have been the royal right of coinage as attested to by gold trientes from around AD 600, whose inscriptions indicate that they were minted by master Gunso in Basle. Three, possibly four of these gold coins have survived: two in Paris in the Cabinet des Médailles, one not clearly legible in the collection of the Hunterian Museum at the University of Glasgow and one was excavated in 2004 in Hégenheim near Basle. It served as an *obolus* in the mouth of a warrior buried in a tumulus in a Merovingian cemetery.<sup>19</sup> So the idea of a royal court in Basle is not new and Berger’s hypothesis is now supported by the recently discovered finds and structures from around the turn of the first millennium.

## 2. 6. 2. The Holy Roman Emperor Henry II and Bishop Adalbero II

Due to the narrow time span covered by the radiocarbon dates, apart from the bishops, only the Kings of Burgundy, Konrad III (AD 937–993) and

Rudolf III (AD 993–1006 and 1024–1032), as well as Henry II (AD 1006–1024) qualify as commissioners and financiers of large building projects on Cathedral hill. In 1006 Rudolf III forfeited Basle to Henry II, who was then King of the Eastern Franks before becoming Holy Roman Emperor in AD 1012.<sup>20</sup> Henry had set up an inheritance contract with his uncle Rudolf to ensure Basle’s incorporation into the Holy Roman Empire after his uncle’s death. However, when Henry died from bladder trouble before Rudolf III in AD 1024 – Rudolf was only three years older – the city fell back to Burgundy. Before AD 1006 when he had first visited Basle, Henry – then still King – had presented Bishop Adalbero II (around AD 999–1025) and his impoverished diocese with generous gifts. It is plausible that at the same time the bishop also received high justice and the right of coinage. Henry II paid for the renovation of the Cathedral, which was dedicated to him and his wife in AD 1019. He donated church ornaments and gave Adalbero a precious bishop’s cloak.<sup>21</sup> Since Henry II and his wife Kunigunde had a very close connection with Basle they were posthumously canonized and venerated as the patron saints of the city.

The construction of a royal residence would be consistent with the building boom initiated by Henry II and his political intentions as a future emperor of the Holy Roman Empire. The inscription *Renovatio regni Francorum* (renovation of the Frankish kingdom) is passed down on his seals as his programmatic declaration.<sup>22</sup> Based on the historical context combined with the radiocarbon dating the mortar mixer and the associated stone building most probably date from between AD 1006 and 1018. At that time the construction project would have been contemporary with the erection of the new two-aisled cathedral, the so-called Heinrichsmünster (Henry’s Cathedral).

Given the important role the city of Basle played from the very beginning and throughout almost the entire medieval period, and bearing in mind the amount and density of archaeological investigations

<sup>16</sup> The ditch was uncovered during the archaeological excavations carried out in 1951 and again in 1978: 1951/52 (Fellmann 1955, 66); 1978/13 (d’Aujourd’hui/Helmig 1980, 246–247).

<sup>17</sup> On a map inserted in the so-called *Erdbebenbuch* (book on the [Basle] earthquake) from 1856 Daniel Fechter shows the boundary of the bishop’s immunity as being situated “behind the chapel of St. John’s” at the southern end of Augustinergasse (Fechter 1856). Ludwig Berger tries to pinpoint that border more accurately with the help of historical sources. He sees the district of episcopal immunity in the tradition with the Late Roman *castrum* (Berger 1965, 157–163).

<sup>18</sup> Berger 1963, 89, 106.

<sup>19</sup> Cf. Unter Uns 2008, 248 (essay by Reto Marti on the Early Middle Ages) and 378 (catalogue); Helmig 2009, 211–213 (comprehensive overview with further references).

<sup>20</sup> In 1011 Neuenburg/Neuchâtel (CH) was mentioned for the first time as *Novum Castellum regalissimam sedem*. In addition, the archaeological evidence proves that Rudolph III built a royal castle there at the beginning of the 11th century (de Reynier 2011). There is no evidence to suggest that he invested in similar projects in Basle.

<sup>21</sup> Pfaff 1963; [http://www.altbasel.ch/dossier/heinrich\\_II.html](http://www.altbasel.ch/dossier/heinrich_II.html).

<sup>22</sup> Cf. Stefan Weinfurter and Karl Görich in: Kirmeier et al. 2002, 186–188, fig. 3 (cat.-n° 59).

carried out, it is astonishing that no mortar mixers were found on Cathedral Hill before now. In actual fact it is highly likely that mortar mixers were used for the construction of Bishop Haito's Cathedral, the so-called Haitomünster<sup>23</sup>, in the first half of the 9th century AD and again at the beginning of the 11th century AD when Henry II had his cathedral built.<sup>24</sup> However, the excavations carried out in 1973/1974 under the direction of Hans-Rudolf Sennhauser uncovered no such features.<sup>25</sup>

## 2. 6. 3. Earlier phases of a royal court?

Returning to the excavation site in "Martinsgasse 6/8" on the northern end of Cathedral Hill, the structures preceding the high medieval mortar mixer are worth investigating more closely: a Late Roman mortar mixing area indicating intense stone building activity in the vicinity was uncovered about 1 m beneath it. Thick layers of 'dark earth' separated the two structures (fig. 2–3). Within the 'dark earth' stratum two occupation surfaces were identified. The lower surface was associated with two pit dwellings and traces of post-built timber structures; these features represent an early medieval phase. While the upper trampling horizon – probably dating from the high medieval period – was also associated with post-built timber structures. In addition, several flat stones purposely placed on this upper occupation surface indicated buildings on sleeper beams. A latrine shaft belonged to the earlier horizon or perhaps to both phases. A handle-like antler object with a ring-and-dot pattern was recovered from the latrine shaft. The artefact itself is difficult to date as similar objects were known from the Roman period right through to the Middle Ages.<sup>26</sup> However, latrines from early and high medieval times are considered very rare and can be viewed as a feature associated with elevated or even luxurious living quarters such as those in a monastery<sup>27</sup>, a bishop's palace

or a royal court. Since the first two options are rather unlikely in this case as discussed above, a Merovingian and/or Carolingian royal court appears to be the most probable association.

## 3. Mechanical mortar mixers in Europe

### 3. 1. History of research

In 1937/38 Emil Vogt was apparently the first archaeologist to excavate one such circular pit with mortar on its base. He published a reconstruction drawing of a pit with a central post and gave it a wattle lining. His description is detailed, but in the end he had to admit that he did not know the original purpose of the device.<sup>28</sup> Other examples were subsequently uncovered in Mönchengladbach (D)<sup>29</sup>, Poznań/Posen (P)<sup>30</sup>, Monkwearmouth (GB)<sup>31</sup>, Schuttern (D)<sup>32</sup>, Pavia (I)<sup>33</sup> and Säben/Sabiona (I).<sup>34</sup> At the time however, none of the excavators understood their original function. They were often interpreted as lime pits or – for example in Poznań/Posen – as the foundations of a baptismal font.<sup>35</sup>

In the 1970s John Williams and Daniel Gutscher independently reached the conclusion that these structures had been mortar mixers. Between 1973 and 1976 John Williams excavated the remains of what he interpreted as three mortar mixers in Northampton. These were published in 1979 and a reference was made to a parallel find in Monkwearmouth.<sup>36</sup> Daniel Gutscher found a similar device

duced in a scriptorium in Reichenau and sent by its abbot Haito to abbot Gozbert of St. Gall (816–837); cf. Simon-Muscheid 1996, 117–118, fig. 102.

<sup>28</sup> Cf. Vogt 1948, 66, fig. 12; Gutscher 1981, 180 s.; Scheidegger 1990, fig. 147.

<sup>29</sup> Borger 1958.

<sup>30</sup> Jósefowiczówna 1967.

<sup>31</sup> Cramp 1969.

<sup>32</sup> List 1975.

<sup>33</sup> Ward-Perkins 1978.

<sup>34</sup> Bierbrauer/Nothdurfter 1988.

<sup>35</sup> Dating from the 10th century the Archbishop's Cathedral of St. Peter and Paul in Poznań – where four mortar mixers were found – is one of the oldest churches in Poland and the oldest Polish cathedral. Historically it represents the beginning of Christianity in Poland. Due to the legend the cathedral was built on the spot where Duke Miesko I was baptised in AD 966. Accordingly the change from a "foundation of a baptismal font" to a "mortar mixer" was of some religious and political significance. See also Gutscher 1981, 184.

<sup>36</sup> Williams 1979.

<sup>23</sup> Sennhauser 1983, 79–84.

<sup>24</sup> Sennhauser 1986, 12–20.

<sup>25</sup> The results of these excavations were not published and the documentation is currently kept in a private archive in Zurzach (CH). According to Hans Rudolf Courvoisier, the technical director of the excavations, it is not possible that remains of mortar mixers were overlooked.

<sup>26</sup> Hagendorn/Stegmüller/Stelzle-Hüglin 2006, 106 fig. 21. Radiocarbon dating the object (Inv.-N° 2004/1.452) would help to date the latrine.

<sup>27</sup> On the so-called Saint Gall monastery plan dated to around AD 820 one of the earliest medieval examples can be seen. Depicting an ideal monastic compound the plan was probably pro-



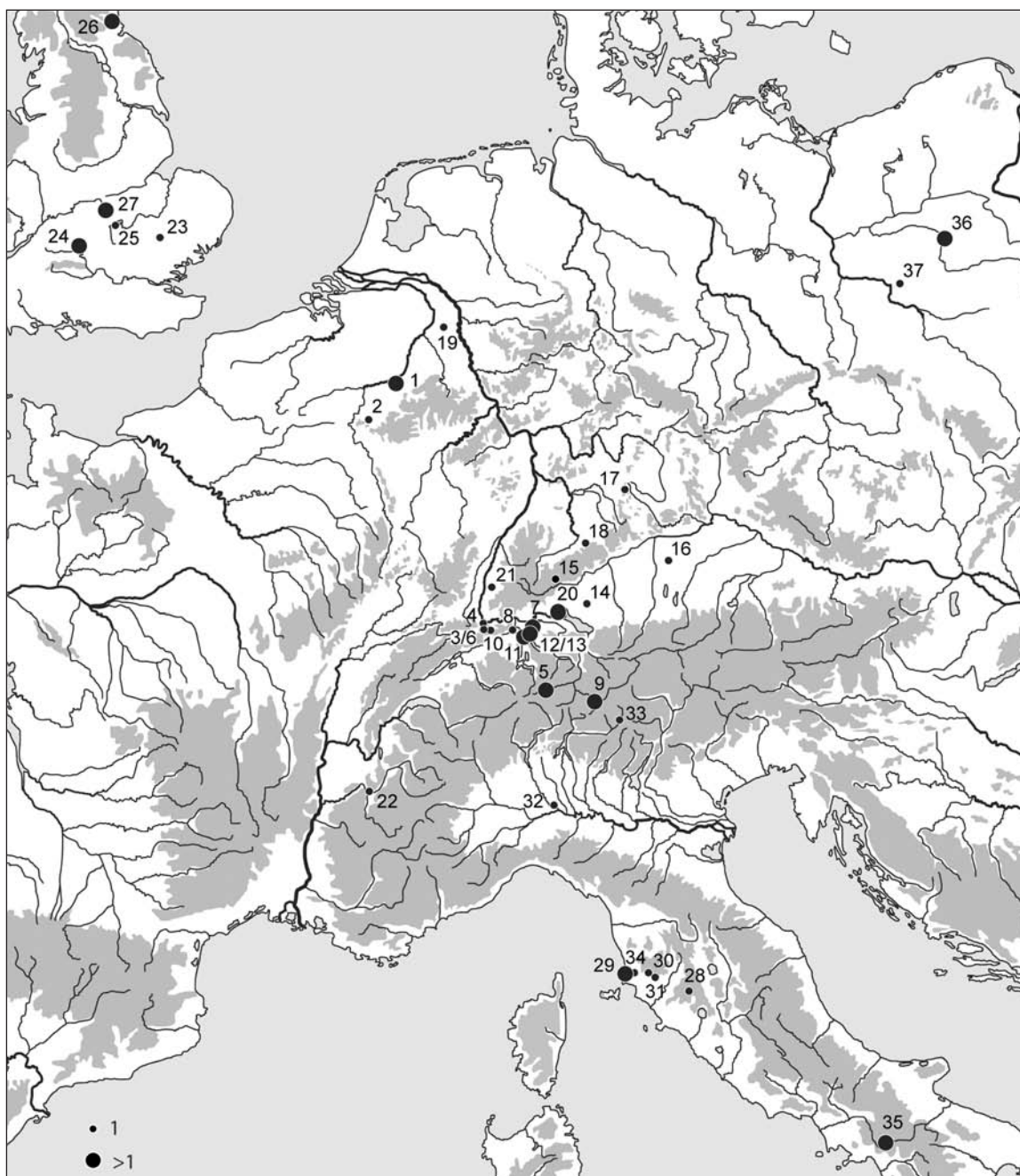


Fig. 10 Geographical distribution of mortar mixer sites (graphics: Peter von Holzen, Archäologische Bodenforschung Basel-Stadt).

at Zurich-Münsterhof in 1977 which he too interpreted as a mortar mixer. In his 1981 publication he drew attention to twelve other examples from eight sites.<sup>37</sup> Meanwhile, between 1980 and 1982, Williams had been involved in the discovery of two further examples in Northampton which were published in 1985. On that occasion, Williams menti-

oned a similar feature in Reichenau, which brought the total number of examples up to 20.<sup>38</sup>

Six years later Renata Windler published three examples from Üetliberg, a presumed early castle site near Zurich, and presented a map of all the known sites – then 17 – bringing the number of known ex-

<sup>37</sup> Gutscher 1981; Schneider/Gutscher/Etter 1982.

<sup>38</sup> Williams 1984, 122–123; 135, Appendix; Williams/Shaw/Denham 1985.



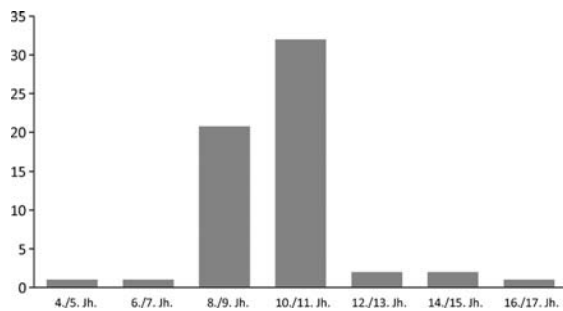


Fig. 11 Chronological distribution of dated mortar mixers (graphics: Sophie Hüglin).

amples up to 29.<sup>39</sup> The map distinguished building contexts and commissioning parties using different symbols for ecclesiastical sites – such as churches, monasteries or bishops’ sees – and secular sites – such as castles and royal courts. The most recent overview was provided by Simon Burnell in his book on a parish church near Basle.<sup>40</sup> His distribution map contains 15 sites while the text mentions four additional sites in Great Britain and Poland.<sup>41</sup> Neither Windler nor Burnell knew of any examples further south than Säben/Sabiona near Bozen/Bolzano in Northern Italy.

### 3. 2. Distribution

The number of excavated mortar mixers has now increased from 39 to more than 60 examples from 37 sites (fig. 10):<sup>42</sup> This includes eleven sites in Switzerland, eight in Germany<sup>43</sup>, eight in Italy<sup>44</sup>, five in Great Britain<sup>45</sup>, two in Belgium, two in Poland and one in France.<sup>46</sup> Intensified archaeological

research over the past forty years, often prompted by construction projects, has resulted in considerably higher numbers of discoveries. At this stage of research the distribution of mortar mixers appears very much concentrated in northern Switzerland and southern Germany with a less dense distribution to the north, east and south. Between 2002 and 2007 six sites in Italy, mainly in Tuscany, have yielded mortar mixers. They were excavated and immediately published online. A short while later they were also made available in print.<sup>47</sup>

France has only one example and the European countries further west have never produced any evidence of mortar mixers. At the congress “Medieval Europe Paris”, I had the opportunity to consult French colleagues directly with regard to any unpublished new discoveries, but there were none. Therefore, the absence of the feature west of the Rhine cannot be explained as a research gap but must have had other reasons such as building traditions and/or conditions.

Sites often contain several mortar mixing devices; Embrach (CH), Müstair (CH) and Northampton (GB) have all yielded five mortar mixers. Some of them appear to have served the same building project, as seen in Northampton, Embrach, Disentis (CH) and Üetliberg (CH). In Müstair, Poznań/Posen (P) and Thier d’Olne (B), on the other hand, they clearly belonged to different periods.

### 3. 3. Dating

Most structures seem to date from the 8th and 9th centuries AD (fig. 11); however, many dates have yet to be verified since they are based on analogies and not on independent dating methods. Grenoble (F) as the earliest example dating from the end of the 4th and beginning of the 5th century stands in isolation. Similarly, Lenzburg (CH) is on its own with a dendrochronological date of AD 1588.

Notwithstanding the problems associated with the dating of the devices, the earlier examples generally appear to have had larger diameters of up to four metres: Grenoble (F), Müstair (CH), Mön-

<sup>39</sup> Windler 1991.

<sup>40</sup> Burnell 1998.

<sup>41</sup> Burnell added Aulendorf (D) with one and Embrach (CH) with four mortar mixers to Windler’s list, which increased the number of examples to 33. He missed out on five mortar mixers from the monastery of Müstair (CH) which had just been published (Sennhauser 1995, 62; 65, fig. 3–4).

<sup>42</sup> Cf. 5. gazetteer. Not included in the gazetteer nor the distribution map (fig. 10) is the site Wallingford, St. Martin’s churchyard (Oxfordshire, GB). The mortar mixer excavated there in 2004 was 2.2 m in diameter and pre-dated a 10th century Anglo-Saxon cemetery (Soden 2010).

<sup>43</sup> Technical term in German: *Mörtelmischer*.

<sup>44</sup> Technical term in Italian: *miscelatore di malta* or *macchina da malta*.

<sup>45</sup> In English two spellings are found: *mortar mixer* and *mortar-mixer*.

<sup>46</sup> Technical term in French: *malaxeur à mortier* or *mélangeur (mécanique) de mortier*.

<sup>47</sup> This seems to reflect intensified research carried out by the Department of Medieval Archaeology at the University of Siena (Dipartimento di Archaeologia e Storia delle Arti di Archaeologia Medievale). Until recently the chair was held by Prof. Riccardo Francovich (†). It has now been taken over by Prof. Marco Valenti.

chengladbach (D), Thier d'Olné (B), Poznań/Posen A (P) and Wiśliza (P); while in the later examples the discs decreased in size and the average diameter lay between two and two and a half metres. While the size of the mortar pit may be seen as a chronological indicator, the builders would have practical reasons to decrease the diameters over time and this would not have reflected the current 'fashion'. Possible explanations will be discussed below in connection with other technical details.

### 3. 4. Technical details

With regard to the construction of medieval mortar mixers Daniel Gutscher identified two different types:<sup>48</sup> Type A had a fixed central post, while in type B the central spindle rotated on a pivot stone together with the attached rake. The feature from Zurich-Münsterhof, which he cited as a prime type A example had four posts outside the mixing pit. Gutscher suggested that these had been used to hold the upper end of the central post in place.

A mortar mixer similar to the Basle example with small and presumably short posts placed inside the mixing pit was found in Mönchengladbach (D).<sup>49</sup> More such examples could probably be cited, but the condition of the structures as well as the documentation and the descriptions given by the researches are often not detailed enough to allow a better understanding of how the devices were constructed and how they worked.

Scheidegger estimated the amount of mortar, that a smaller mixer with a maximum diameter of 2.5 m could produce mortar loads of between half a ton and two tons in weight; accordingly, the bigger devices would have yielded two to three tons of mortar per cycle.<sup>50</sup>

He also offered his thoughts on possible driving powers: he calculated that it would require four men or one ox or horse to effectively run one of the smaller devices.<sup>51</sup> A mechanical mortar mixer of this type

could probably produce 50 m<sup>3</sup> of mortar per day, which is three times as much as a team of 15 workers can manually produce in the same period of time. Such large quantities of mortar were mainly required to cast mortar floors or to plaster large wall surfaces. Scheidegger, however, believes that the mortar was mainly used in shell constructions: two outer shells of a stone wall were built up and the centre subsequently filled with uncut stone fragments; large quantities of semi-liquid mortar were then needed to fill the cavities.<sup>52</sup> Foundations and vaults of Carolingian and Romanesque buildings required particularly large amounts of concrete-like lime mortar. Much less mortar would have been needed for a Gothic cathedral since the stones were carefully cut; so a wall did not need to be as thick in order to carry the static load.

Once the stone masons had completed their work the wooden parts of the mortar mixer could easily be dismantled and brought to the next building site. This would have made it an ideal device for a group of craftsmen moving from site to site.

### 3. 5. Historical sources – texts and illustrations

The classical author Vitruvius in his *De architectura*, a comprehensive account of Roman building techniques in ten volumes, does not mention a mechanical apparatus for the preparation of mortar. On the other hand mixing by hand is depicted on Roman wall paintings and mosaics. Thus, the literary, pictorial and archaeological sources agree that mechanical mortar mixing was not an invention of antiquity, but of the Middle Ages.<sup>53</sup>

Information possibly referring to mortar mixers can be taken indirectly from Anglo-Saxon and Lombard written sources. The texts reflect the situation in the 7th and 8th centuries AD and report both on the contractors and the builders themselves: Bede's (\* 673 near Wearmouth, † 735 in Jarrow) biography of the abbots of at the Northumbrian monastery of Saint Peter in Monkwearmouth describes the life of Benedict Biscop (628–690) in the late 7th century.<sup>54</sup> Before founding the twin-monastery of Wearmouth-Jarrow, Benedict Biscop travelled to the continent several times. From "Francia" he brought back builders

<sup>48</sup> Gutscher 1982, fig. 64.

<sup>49</sup> Gutscher 1981, 182–184.

<sup>50</sup> Scheidegger 1999, 252, tab. 1–2.

<sup>51</sup> C. Wapples (Williams 1979, 125; 129) suggested that two men would not be able to drive the Northampton mixers and that it would take either four men or two animals. Apart from the pure force and speed an animal is capable of, it is very important to take into account how they might have been harnessed at any given time. This aspect will be discussed below (see 3. 5.).

<sup>52</sup> Scheidegger 1999, 244.

<sup>53</sup> Williams 1979, 119; Cech 2011, 45–46.

<sup>54</sup> Vita Beatorum Abbatium I, 4–5.

and specialised craftsmen with him, who were hired to help building and furnishing the abbey.

Although they are some of the oldest examples known, the mortar mixers from Wearmouth and probably also those from Northampton obviously represent an imported construction technique. With the exception of the examples from Poland and southern Italy, all the known sites could be identified as having been part of “Francia”, the region mentioned by Bede. Due to the lack of archaeological evidence present-day France itself does not seem to have been the area where the builders had come from.

An early legal text from the Lombard Kingdom in northern Italy, written from the mid 7th to the mid 8th centuries AD, explicitly mentions the adequate payment for many tasks associated with construction. In it, the executing party is called *magistri/maestri commacini*, a group of builders and craftsmen famous both at the time and well into the modern era. To this day the correct interpretation of their name remains a matter of debate.<sup>55</sup> The adjective can be interpreted either geographically – in which case *com(m)acino* would mean “from the region of Como” – or as a specification of their work – in which case *commacino* would be translated as “with machines”. Here the suffix would derive from *cum mako*, *mako* being a word of Germanic origin. Transformed into Latin *mako* would turn into “macio”, which again gave us the English word “mason” and the French term “maçon”.

The Latin term *machina* was derived from the Greek *μηχανή* often used by Vitruvius and Pliny. Vitruvius in his “De architectura” (10.1.1) defines *machina* as follows: “A ‘machine’ is a device made of solid pieces of wood with a great power to accomplish tasks based on the principles of circular movement as defined by the Greeks.” With regard to construction techniques the meanings of “crane”, “hoist” and “scaffolding” are also attested to have been described with the term.<sup>56</sup>

Without discussing all the philological aspects in detail, the interpretation as *cum macinis* for the *magistri/maestri commacini* seems to make most sense, both from an archaeological and from a practical point of view: after all machines such as cranes and mortar mixers were the most outstanding features of a professional construction site in the High Middle Ages. To this very day the terms *Maschinist* (Ger-

man), *machiniste* (French), *macchinista* (Italian) are used on modern building sites to denote the operators of cranes and large excavators. We must be aware though that the term *machina* in medieval Latin was not used in the way the term *machine* was defined in early modern times.<sup>57</sup>

A passage in the *Leges Langobardorum*<sup>58</sup> lists prices for walls of different thicknesses and lengths. Some sort of mechanical device is also mentioned: *Si vero macinam mutaverit* (“Should the machine have to be moved”). One would like to know what kind of machine this refers to. Besides a crane it could also be a mortar mixer. Many sites have yielded several mortar mixing devices so that mortar could be produced as close as possible to the walls under construction.

Surprisingly, no medieval depictions of mortar mixers have been found up to date, though building sites are quite a common motif in late medieval manuscripts such as bibles and chronicles, but also on stained glass in cathedrals, church murals and ornaments or tapestries.<sup>59</sup> The illustrations often depict scenes from the bible, especially the construction of the Tower of Babel, or commemorate the foundation of specific sites: they show workers mixing sand, lime and water with iron clad shovels and hoes often with the help of wooden boards and protected by a roof. Once ready the mortar is then carried in different containers<sup>60</sup> up the scaffolding or hauled up with the help of a crane or winding tackle. Most illustrations are also very detailed with regard to the technical devices and appear to have been produced by contemporary observers with a first-hand knowledge of medieval building sites. Why then are there no depictions of mechanical mortar mixers? Mortar mixers seemingly were no longer used in the 13th to 15th centuries, when so many of these illustrations were produced. One reason could be the change in stone architecture and construction techniques between the Romanesque and Gothic eras as mentioned above and with it the much reduced

<sup>57</sup> Popplow 1996.

<sup>58</sup> Item Memoratorio de Mercedes Commacinorum, 2. Si vero murum fecerit.

<sup>59</sup> Binding published originals and line drawings of more than 30 depictions of construction sites showing workers mixing mortar by hand (Binding 1993, fig. 1; 4; 5; 9; 10; 12; 14–17; 20; 22; 24; 69; 70; 123; 127; 138; 140; 150; 156; 158; 159; 162; 172–174; 183; 187; 191–193).

<sup>60</sup> These could be wooden bowls, troughs (with handles for one or two labourers), buckets, baskets or a so-called “bird” (from Latin *avis*; the technical term was translated into German *Vögel* and French *oiseau*) two boards at right angles with two handles to be carried on the shoulders (Binding 1993, 377–386).

<sup>55</sup> Salmi 1971, 409; Erb 1982; Lomartire 1996, 139

<sup>56</sup> Healy 1999, 162, notes 43 and 44; Fleury 1993, 35 ss.

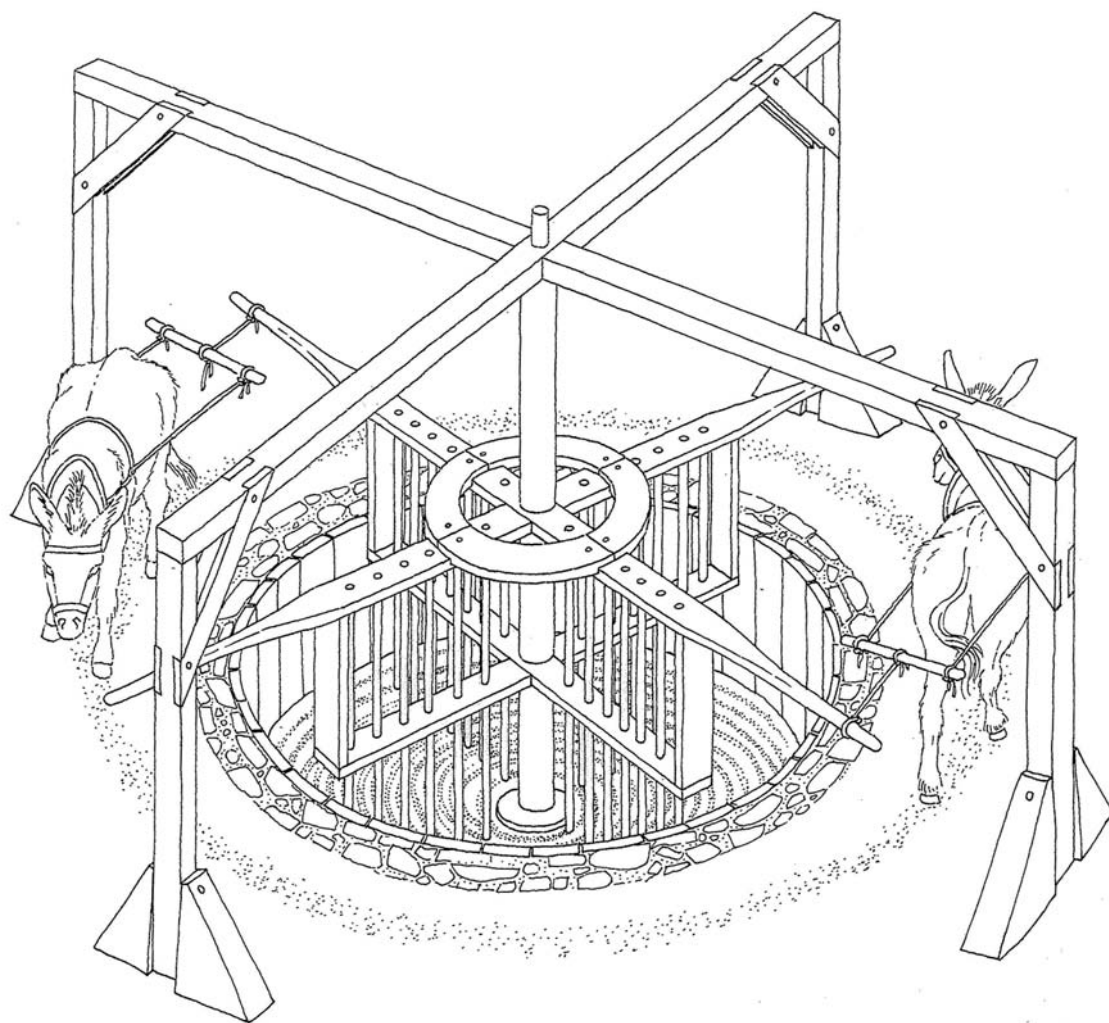


Fig. 12 Proposed reconstruction of the Lenzburg (CH) mortar mixer. The supposedly four-armed rake is drawn here by two mules wearing some kind of a collar in combination with a wippletree (illustration: Ruth Baur, Kantonsarchäologie Aargau).

need of large quantities of mortar within a short period of time. In late medieval times building in stone was no longer the exception and professional “mortar makers” are mentioned in German and French texts, although their pay equalled that of unskilled workers.<sup>61</sup>

### 3. 6. Reconstructions – driving power

The open-air museum in Tilleda (D) – the site of a former royal court – is the first institution to have created a life-sized reconstruction of a mortar mixer.<sup>62</sup>

No further information was available on the motivation – other than tourism – behind it or reports on the experience gained. Nevertheless an experimental reconstruction of mortar mixers would provide an excellent opportunity to put the theoretical considerations and the reconstruction drawings discussed here to the test.

Many researchers – generally in cooperation with illustrators – have produced reconstruction drawings of the mortar mixers they have excavated: apart from Basle (fig. 7) other features presented with the addition of a reconstruction drawing (fig. 12) were those uncovered in Zurich-Lindenhof (CH)<sup>63</sup>, Northamp-

<sup>61</sup> Binding 1993, 313–315.

<sup>62</sup> The site itself, however, did not yield any remains of a medieval mortar mixer.

<sup>63</sup> Vogt 1948, 66, fig. 12 (aware of not being able to identify its purpose Vogt presented the pit without a wooden superstructure).



ton (GB)<sup>64</sup>, Zurich-Münsterhof (CH)<sup>65</sup>, Mönchengladbach (D)<sup>66</sup>, Kirchheim/Teck (D)<sup>67</sup> and Lenzburg (CH).<sup>68</sup> While the technical details of the devices have already been discussed the driving power is worth examining more closely. Nearly all authors consider the possibility of animals instead of labourers having been used to rotate the arms of the mortar mixers. However, only Weber and the illustrator Baur went as far as to show two mules turning the mill in their example from Lenzburg. The late date of this structure – post AD 1588 – is an advantage here because it allowed Weber and Baur to use recent ethnological parallels such as capstans driven by horses or donkeys from the Mediterranean or Early Modern examples.<sup>69</sup> There is very little evidence pointing to the animals used to move carts, ploughs and of course mortar mixers during the 7th to 11th centuries AD. By choosing animal power in an attempt to merely show the functionality of a mechanical device one automatically initiates a discussion concerning the characteristics of species such as cattle, horses, donkeys and mules as well as their respective breeding history. In addition, there are a plethora of possible towing devices and harnesses, which are extremely rare and difficult to date, both as archaeological artefacts and literary sources.

Harnessing a pair of oxen to a mortar mixer would require a head or neck yoke, the latter being held in place around the necks of the animals by u-shaped oxbows. While a stiff yoke works well in front of a plough it is not suitable for the tight curve around a mortar mixer. This would require a lot of space, which is not available in the reconstructed four-post construction or on a crowded building site. Therefore, the animal(s) would have had to walk in single file. In order for the horse, donkey or mule to be able to drag heavy loads efficiently while still breathing properly a different kind of harness was required: a collar. The earliest collars are known from China from where they spread across Europe around AD 920 and became

universally used by the 12th century.<sup>70</sup> A predecessor of the collar, the breast collar or breast-strap harness – also with Chinese forerunners and almost as effective as the collar – can be seen in European artwork as early as the 8th century AD.<sup>71</sup> A so-called wippletree divides the forces evenly behind the collar-like harness and prevents the leather from rubbing against the animal's shoulders. Wippletrees were already known in European prehistory, more specifically since the 3rd century BC. An 11th century AD illustration shows one in combination with a collar.<sup>72</sup> At somewhat of a stretch the archaeological and historical evidence from the 8th century onwards would support the Lenzburg reconstruction showing a mortar mixer being driven by two mules wearing a (breast) collar combined with a wippletree.

The possibility of using animals instead of humans to produce mortar might have been one of the driving forces behind the construction of the mechanical device. For some reason – be it low productivity or lack of skilled labourer – it seems to have been an advantage for a certain period to replace humans by animals. Before this period and afterwards – in Roman times and again in the Late Middle Ages – slaves and workers were obviously cheap enough to produce the mortar required by hand.

#### 4. Discussion and outlook

Historical sources from Anglo-Saxon England suggest that the builders who used mortar mixers to construct outstanding ecclesiastical stone buildings in England in the late 7th century may have come from “Francia”. Some of these specialist builders who were on the move between southern Italy and Northumbria, the River Rhine and Poland may have been referred to by the term *magistri commacini* mentioned in Lombard legal texts. These contract builders would have worked for a powerful and wealthy elite from the ecclesiastical and secular realms. When travelling countries where construction was predominantly in timber these specialist craftsmen must have encountered numerous difficulties including perhaps a general lack of suitable building material, skilled workforce or even unskilled labourers, and they may also have had problems communicating with local

<sup>64</sup> Williams 1979, 118 fig. 67.

<sup>65</sup> Gutscher 1981, 185, fig. 17 (type B) and 186, fig. 19.

<sup>66</sup> Gutscher 1981, 185, fig. 17 (type A).

<sup>67</sup> Schäfer 1987, 272, fig. 206 (almost completely copied from Gutscher 1981, 185, fig. 17, type A).

<sup>68</sup> Weber 2004, fig. 12.

<sup>69</sup> While in the Mediterranean capstans are today mainly used in agriculture, for example in oil mills, the early modern mining industry used them to haul heavy loads or scoop water. While donkeys appear to have been used more often in the south, horses seem to have been more common in the north.

<sup>70</sup> Needham 1986, 317.

<sup>71</sup> Needham 1986, 315.

<sup>72</sup> Hayen 1983, 465.

people. The three last-mentioned aspects might have made it seem easier to construct devices which could be driven by animals or unskilled workers and which could be used to prepare large amounts of mortar.

Mortar mixers as found in archaeological excavations have often prompted attempts to identify the specific potentate who might have funded the extravagant building. Basle has also yielded substantial archaeological and historical evidence to link the mortar mixer with the construction of a stone building which may have been part of a royal residence on the Martinskirchsporn, possibly built by Henry II at the beginning of the 11th century.

Without the overwhelming archaeological evidence for this mechanical device it would have long been forgotten. No literary or pictorial sources are available that would prove its existence or help with its reconstruction. Future excavators will uncover

other mortar mixers both at sites already known and at new sites, which will be added to the distribution map. However the records of earlier finds should be reassessed with new questions in mind. As many as possible of the “old” structures should be dated independently. If there are any remnants of the original mortar, it could be analysed by means of AMS radiocarbon dating or other natural scientific methods. Also, different types of mortar mixers should be built and tested by experimental archaeology.

From the 8th to the 11th centuries mortar mixers and other large-scale mechanical devices like cranes were the landmarks of large building sites. The specialists using them worked all over Europe for the secular and ecclesiastical elite. For further research into this phenomenon, it will be necessary to cross present-day geographical, social, linguistic and professional borders at least within Europe.

## 5. Gazetteer

The numbers correspond to the map in fig. 10.

N°	Site	Technical data (diameter, type)	Dating (archaeologically, historically, etc.)	Reference(-s)
<i>Belgium</i>				
1	Thier d’Olne, Huy (Province of Liège, Wallonia) 1	approximately 4 m	mid of 8th to early 9th centuries AD (arch.)	Witvrouw 2005
1	Thier d’Olne, Huy (Province of Liège, Wallonia) 2	approximately 2 m	9–10th centuries AD (arch.)	Witvrouw 2005
2	Wellin, Neufchâteau (Province of Luxemburg, Wallonia) church near Wellin	approximately 2 m	possible connection with 13/14th century AD pottery	Archéologia 114, 1978, 69; Archéologia 129, 1979 82; Williams/Shaw/Denham 1985, 36–37; Évrard 1986
<i>Switzerland</i>				
3	Aesch-Saalbünten (Canton Basel- Landschaft) inside remains of a church	approximately 2 m	10th century AD (arch.); cuts through an older church floor; possible connection with the Kingdom of High Burgundy	Tauber 1985; Marti 2000; <a href="http://www.archaeologie.bl.ch/Pages/Ausgrabungen/aesch-saalbuenten.htm">http://www.archaeologie.bl.ch/ Pages/Ausgrabungen/aesch- saalbuenten.htm</a>
4	Basle, Martinsgasse 6/8 (Canton Basel-Stadt)	approximately 2.5 m, enforced mixing principle (Zwangsmischer)	AD 936–1018 with 71.8% probability (14C-AMS-dating); possible connection with Holy Roman Emperor Henry II (arch.)	Hagendorn/Stegmüller/Stelzle-Hügli 2006
5	Disentis, St. Martin (Canton Graubünden) 1 (N° 525)	approximately 2.8 m	8–9th centuries AD, cut by grave 85 (arch./hist.)	Schneider/Gutscher/Etter/Hanser 1982, 73; 146, fn. 29; Windler 1991, fn. 68, Scheidegger 1990, 250 s.
5	Disentis, St. Martin (Canton Graubünden) 2 (N° 681)	approximately 2.8 m	8–9th centuries AD (arch./hist.)	Schneider/Gutscher/Etter/Hanser 1982, 73; 146, fn. 29; Windler 1991, fn. 68, Scheidegger 1999, 250 f.

5	Disentis, St. Martin (Canton Graubünden) 3 (N° n/a)	n/a	8–9th centuries AD (arch./hist.)	Schneider/Gutscher/Etter/Hanser 1982, 73; 146, fn. 29; Windler 1991, fn. 68, Scheidegger 1990, 250 f.
6	Dornach, Kohliberg 6 (Canton Solothurn)	approximately 2 m	possible connection with nearby late medieval stone building	Nold 2004
7	Embrach, Pfarrhausstrasse (Canton Zurich) 1	2.2–2.4 m	former monastery first mentioned in AD 1044 (hist.)	Matter 1994, esp. 244 fig. 164
7	Embrach, Pfarrhausstrasse (Canton Zurich) 2	2–2.2 m	AD 1027–1243 with 95.4% probability (radiocarbon dating)	Matter 1994, esp. 244 fig. 164
7	Embrach, Pfarrhausstrasse (Canton Zurich) 3	approximately 1.8 m	former monastery first mentioned in AD 1044 (hist.)	Matter 1994, esp. 244 fig. 164
7	Embrach, Pfarrhausstrasse (Canton Zurich) 4	1.8 m	AD 561–780 with 95.4% probability (radiocarbon dating)	Matter 1994, esp. 244 fig. 164
7	Embrach, Pfarrhausstrasse (Canton Zurich) 5	n/a	former monastery first mentioned in AD 1044 (hist.)	Matter 1994, esp. 244 fig. 164
8	Lenzburg, Eisengasse (Canton Aargau)	2.75 m	post AD 1588 (Dendrochronology)	Küng 2004; Weber 2004
9	Müstair-St. Johann, monastery (Canton Graubünden) 1	approximately 3.5 m	Carolingian (history of art)	Sennhauser 1995, esp. 62; 65 fig. 3–4
9	Müstair-St. Johann, Plantaturm (Canton Graubünden) 2	approximately 2 m	AD 958 (hist.)	Sennhauser 1995, esp. 62; 65 fig. 3–4
9	Müstair-St. Johann, Plantaturm (Canton Graubünden) 3	approximately 2 m	AD 958 (hist.)	Sennhauser 1995, esp. 62; 65 fig. 3–4
9	Müstair-St. Johann, Plantaturm (Canton Graubünden) 4	approximately 2 m	AD 958 (hist.)	Sennhauser 1995, esp. 62; 65 fig. 3–4
9	Müstair-St. Johann, Plantaturm (Canton Graubünden) 5	approximately 2 m	AD 958 (hist.)	Sennhauser 1995, esp. 62; 65 fig. 3–4
10	Sissach, protestant church (Canton Basel- Landschaft)	2.5 m	8–9th centuries AD (arch./typologically); connection with church phase II	Tauber/Hartmann 1988; Burnell 1998, esp. 36–47; Marti 2000
11	Üetliberg, Uto-Kulm (Canton Zurich) structure 324	2.4 m	10th century AD (arch.)	Windler 1991
11	Üetliberg, Uto-Kulm (Canton Zurich) structure 319	2.65 m	10th century AD (arch.)	Windler 1991
11	Üetliberg, Uto-Kulm (Canton Zurich) structure 285	n/a	10th century AD (arch.)	Windler 1991
12	Zurich, Münsterhof (Canton Zurich) monastery	2.9 m	connection with <i>Monasterium Thuricense</i> (Fraumünster Abbey) AD 853–874; destroyed by the first phase of the graveyard (arch./hist.)	Schneider/Gutscher /Etter/Hanser 1982; Gutscher 1981
13	Zurich, Lindenhof (Canton Zurich) imperial palace 1	2.6 m	connection with Carolingian “Kaiserpfalz” (arch./hist.)	Vogt 1948; Gutscher 1981; Küng 2008

13	Zurich, Lindenhof (Canton Zurich) imperial palace 2	< 2.6 m	destroyed by a timber structure of possible Carolingian date (arch.)	Vogt 1948; Gutscher 1981; Küng 2008
13	Zurich, Lindenhof (Canton Zurich) imperial palace 3	2.9 m	connection with Carolingian "Kaiserpfalz" (arch./hist.)	Vogt 1948; Gutscher 1981; Küng 2008
<i>Germany</i>				
14	Aulendorf, Schloß (District Ravensburg, Baden-Württemberg), castle	approximately 2.5 m	predates 10th century AD stone building (arch.)	Schmidt 1995, fig. 164
15	Bärental (District Tuttlingen, Baden- Württemberg), church	2.30 m	connection with remains of stone church and graveyard; graves radiocarbon dated 7th–10th century AD; mortar mixer destroyed by grave 57 (arch.)	Klug-Treppe 2010, 199, fig. 117; 201
16	Burg Wittelsbach (District Aichach-Friedberg, Bayern), castle	approximately 2.2 m	10–11th centuries AD, „before AD 1210“	Gutscher 1988, 180; Windler 1991, fn. 72
17	Herrieden, Stiftskirche (District Ansbach, Bayern), church	approximately 3 m	10–11th centuries AD (arch.)	Steeger 2005
18	Kirchheim/Teck, Widerholtplatz (District Esslingen, Baden- Württemberg)	approximately 2.5 m	possible connection with earlier phase of St. Martin's church; first mentioned in AD 970 as <i>basilika decimalis</i> (hist.)	Schäfer 1987, esp. 272 fig. 206; 273
19	Mönchengladbach, St. Vitus Minster (Nordrhein-Westfalen) monastery	3.4 m, enforced mixing principle (Zwangsmischer)	predates the foundation of the monastery in AD 974 (arch./hist.)	Borger 1958; Gutscher 1981
20	Reichenau, Mittelzell (District Konstanz, Baden-Württemberg) monastery	n/a	late 9th to early 10th century AD	Zettler 1988, 181–182 fig. 50–51
20	Reichenau-Mittelzell (District Konstanz, Baden-Württemberg) monastery	approximately 2.5 m	possible connection with St. Laurentius' church, consecrated prior to AD 1056 (hist.)	Schmidt-Thomé 2007
21	Schuttern, Reichsabtei (District Offenburg, Baden-Württemberg) imperial abbey church	2.6 m	early 9th century AD (arch.)	List 1975; Gutscher 1981, 182 ss.
<i>France</i>				
22	Grenoble (Isère Department) cathedral	3.60 m	late 4th to early 5th century (arch.)	Baucheron et. al. 1998
<i>Great Britain</i>				
23	Duxford (Cambridgeshire)	approximately 2.5 m	14th–15th centuries AD, possible connection with building activity around St. Peter's church (arch.)	Lyons forthcoming
24	Eynsham, Ælfric's Abbey (Oxfordshire) structure 5187, mortar (130)	2.2 m	AD 1005–1070 (phase 2f defined arch./hist.)	Hardy/Dodd/Keevil 2003, 26, fig. 2.1; 73, fig. 3.20–3.21; pl. 3.6



24	Eynsham, Ælfric's Abbey (Oxfordshire) structure 5187, mortar (145)	2.25 m	AD 1005–1070 (phase 2f defined arch./hist.)	Hardy/Dodd/Keevil 2003, 26, fig. 2.1; 73, fig. 3.20–3.21
25	Leighton Buzzard, Fontevraldine Priory of La Grava/Grove Priory (Bedfordshire)	approximately 2 m x 1.3 m	late 12th century AD (arch.)	Baker forthcoming
26	Monkwearmouth Abbey (Sunderland, Tyne and Wear), Anglo Saxon monastery, Structure A or 1490	3.20–3.65 m	late 7th–8th centuries AD, cut by Late Saxon or Norman graves (arch.)	Cramp 1969, 30, fig.13; 32, fig. 14 (“floor” of Building A); 34, fig. 15 (mortar “floor”); Cramp 2005, 93–94, fig. 9.4, 9.5, 9.8
26	Monkwearmouth Abbey (Sunderland, Tyne and Wear), Anglo Saxon monastery, Structure 776	approximately 3.5 m	late 7th–8th centuries AD (arch.)	Cramp 2005, 101, fig. 9.19, 9.36, 9.37
27	Northampton, St. Peter's church, Anglo-Saxon palace and minster 1	2.2 m	early 9th century AD or Middle Saxon period (arch.)	Williams 1979, 119–121; fig. 68; pl. 31
27	Northampton, St. Peter's church, Anglo-Saxon palace and minster 2	3.0 m	early 9th century AD or Middle Saxon period (arch.)	Williams 1979, 121–123; fig. 69; pl. 32–35
27	Northampton, St. Peter's church, Anglo-Saxon palace and minster 3	2.2 m	early 9th century AD or Middle Saxon period (arch.)	Williams 1979, 123–125; fig. 70–71; pl. 36–42
27	Northampton, St. Peter's church, Anglo-Saxon palace and minster 4 (W129)	2.4 m	early 9th century AD or Middle Saxon period (arch.)	Williams/Shaw/Denham 1985, 21–24; fig. 11–12; pl. 15–16
27	Northampton, St. Peter's church, Anglo-Saxon palace and minster 5 (W50)	2.4 m	early 9th century AD or Middle Saxon period (arch.)	Williams/Shaw/Denham 1985, 21; 24–26; fig. 13; pl. 17–18

#### *Italy*

28	Abbazia San Salvatore al Monte Amiata (Siena, Tuscany), monastery	approximately 2 m	11th century AD	Dallai 2003
29	Castello di Donoratico, Castagneta Carducci (Livorno/Leghorn, Tuscany), castle 1	n/a	9th century AD?	Bianchi 2010, 75, fig. 3.
29	Castello di Donoratico, Castagneta Carducci (Livorno/Leghorn, Tuscany), castle 2	n/a	n/a	Bianchi 2010, 75, fig. 3.
29	Castello di Donoratico, Castagneta Carducci (Livorno/Leghorn, Tuscany), castle 3	n/a	n/a	Bianchi 2010, 75, fig. 3.
30	Castello di Miranduolo (Chiusdino, Siena, Tuscany), castle	approximately 1.70 m	9th/10th century AD	Nardini/Valenti 2007

31	Castello di Montemassi (Grosseto, Tuscany), castle	n/a	14th century AD	Bruttini et al. 2002
32	Torre Civica di Pavia (Lombardy)	approximately 1.2 m	11th century AD	Ward-Perkins 1978
33	Säben/Sabiona (Bozen/ Bolzano, Trentino-Alto Adige), monastery and episcopal see	approximately 3 m	n/a	Bierbrauer/Nothdurfter 1988, 258, insert 4; 262 s., pl. 6
34	San Pietro in Monteverdi, Monteverdi Marittimo (Pisa, Tuscany), monastery	n/a	9th century AD	Francovich/Bianchi 2006
35	San Vincenzo al Volturno 1 (Isernia, Molise), monastery	approximately 3 m	mid of 11th century AD	Riddler 1993, esp. 206–208
35	San Vincenzo al Volturno 2 (Isernia, Molise), monastery	n/a	n/a	(personal communication Federico Marazzi, September 2007)

#### Poland

36	Poznań/Posen A, cathedral	approximately 4 m	3rd quarter of the 10th century AD	Jósefowiczówna 1967; Gutscher 1981; Williams/Shaw/Denham 1985, 36–37
36	Poznań/Posen B, cathedral	1.1 m	3rd quarter of the 10th century AD	Jósefowiczówna 1967; Gutscher 1981; Williams/Shaw/Denham 1985, 36–37
36	Poznań/Posen C, cathedral	n/a	3rd quarter of the 10th century AD	Jósefowiczówna 1967; Gutscher 1981; Williams/Shaw/Denham 1985, 36–37
36	Poznań/Posen D, cathedral	n/a	3rd quarter of the 10th century AD	Jósefowiczówna 1967; Gutscher 1981; Williams/Shaw/Denham 1985, 36–37
37	Wisłiza/Wiesling, (east of) parish church	4 m	connection with 9th century AD pottery, destroyed by 10th century AD church (arch.)	Jósefowiczówna 1967; Gutscher 1981; Williams/Shaw/Denham 1985, 36–37

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*Zusammenfassung: Mittelalterliche Mörtelmischer neu betrachtet. Basel und anderswo*

Mechanische Mörtelmischer stehen in Zusammenhang mit der Wiedereinführung von Steinarchitektur in Zentraleuropa zwischen dem 8. und 11. Jahrhundert n. Chr. Sie scheinen vor allem auf solchen Großbaustellen Verwendung gefunden zu haben, deren Auftraggeber zu den hohen kirchlichen und weltlichen Herrschern gehörten. Als zuletzt in Basel ein sehr gut erhaltenes Beispiel ausgegraben wurde, war es zum ersten Mal möglich die Funktionsweise detailliert zu rekonstruieren, zum anderen begann die Suche nach dem zugehörigen Steingebäude und dessen Auftraggeber. Kleinste Holzkohlepartikel in der Mörtelmischscheibe konnten <sup>14</sup>C-datiert werden und ergaben mit hoher Wahrscheinlichkeit eine Nutzung zwischen 936 und 1018 n. Chr. Zusammen mit wiedergenutzten spätrömischen Steinbauten und einer außergewöhnlichen Goldschmiedearbeit mit Emailleinlagen weisen auf den möglichen Bauherrn hin: Kaiser Heinrich II. Frühere Forscher haben auf dem Martinskirchsporn, dem Nordende des Basler Münsterhügels, einen fränkischen Königshof vermutet. Die neuen Funde stützen diese Theorie und legen nahe, dass dieser auch noch unter den Karolingern und Ottonen genutzt und ausgebaut wurde. Der zweite Teil des Beitrags befasst sich mit dem europäischen Phänomen der Mörtelmischer. Zehn Jahre nach der letzten Übersichtsdarstellung hat sich die Zahl der bekannten Beispiele verdoppelt. Es sind momentan über 60 Befunde von 38 Fundstellen, die sich zwischen Neapel und Newcastle upon Tyne, Brüssel und Posen verteilen. Technisch können mehrere Anlagentypen unterschieden werden. Einige Merkmale – wie z. B. der Durchmesser – scheinen typisch für eine bestimmte Epoche zu sein. In den schriftlichen Quellen finden sich Hinweise auf die mögliche Herkunft der Bauspezialisten. Die möglichen Antriebe der Göpel – durch Menschen oder Tiere – werden diskutiert. Die breit angelegte Recherche sucht nach Gründen, warum diese Maschinen zu einer bestimmten Zeit weite Verbreitung fanden, aber weder zuvor und auch kaum noch hinterher verwendet wurden.

*Abstract: Medieval Mortar Mixers Revisited. Basle and Beyond*

Mechanical mortar mixers are connected with the reintroduction of stone architecture in 8th to 11th century Central Europe. They often appear to have been associated with large building projects commissioned by high ecclesiastical and secular rulers in the High Middle Ages. When a well-preserved example was found on Basle Cathedral Hill, it was an opportunity to both study its function in detail and search for the associated stone building and its contractor. Minute flecks of charcoal in the mortar disc were radiocarbon dated with a high probability to between AD 936 and 1018. Together with rebuilt Late Roman stone structures and an exceptional piece of enamelled gold-work, a potential contractor for the building site comes into focus: Holy Roman Emperor Henry II. Researchers previously believed the northern tip of Cathedral Hill might have been the site of a court of the Frankish Kings. The new finds support this theory and suggest that this court was used and developed by the representatives of the Carolingian and Ottonian dynasties. The second part of the article assesses mortar mixers as a European phenomenon. More than ten years after the last comprehensive overview the number of examples has doubled. More than 60 structures from 38 sites are known between Naples and Newcastle upon Tyne, Brussels and Posen. Technologically different types of devices can be identified. Some characteristics – including a mortar pit with a large diameter – seem to have been limited to a certain period. Written sources provide clues regarding the provenance of the specialist builders themselves. The possible driving powers – man or animal – are also discussed. The broadly based investigation attempts to identify the reasons why these machines flourished at a certain time but were only rarely used before or after.